EGYPT'S EXPERIENCE WITH REGARD TO WATER DEMAND MANAGEMENT IN AGRICULTURE

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1. Introduction

Egypt is an arid country with rapid population growth and escalating living standards. According to the World Bank projections, Egypt's population is projected to reach 86-100 million people by 2025. The natural and geographical conditions of Egypt are not auspicious in terms of fresh water resources availability.

The traditional approach of water-use considers water as a "requirement" which must be met by developing additional water resources; i.e. water supply management.

The new approach of water demand management seeks for reaching the equilibrium level of the limited water resources and the increasing demand for water.

The simplest definition of "water demand management" is that provided by the International Development Research Centre (IDRC); "water demand management is to get the most from the water we have".

The main and almost exclusive source of fresh water in Egypt is the River Nile. Egypt's share of the River Nile water constitutes the largest amount of its renewable water supply. The rest is in the form of scattered rainfall and groundwater.

The population growth and rising living standards have put more stress on both land and water resources. Increased industrial growth together with intensified agriculture also has a direct impact on surface as well as groundwater quality. Availability of water is also constrained by its degraded quality, which limits its use for specific purposes.

Due to the limited available water resources, it is essential to increase water-use efficiency; recycling and reusing available water resources to develop unconventional water resources. Hence, scarcity of water resources has dictated the need to use different types of low quality water and increase the horizontal land expansions.

The Government of Arab Republic of Egypt (GOE) has adopted the horizontal expansion of cultivated lands as a major policy to increase crop production. Further land reclamation using Nile water is difficult to forecast. Reclamation of some desert areas using fossil water is possible but is not economical and is not feasible. The GOE has launched several policies aiming to better utilization of the limited water resources and increase the efficiency of water-use in all sectors. The main objective of these policies is to utilize the available conventional and non-conventional water resources to meet the socio-economic and environmental needs of Egypt as well as preserve the biodiversity and conserve the environment.

Irrigation structures rehabilitation, improvement of the irrigation system, installation of water level monitoring devices linked to the telemetry system, expansion in the tile drainage system, etc. There are also several non-structural measures that have also been implemented including programmes for cost recovery, institutional reforms, laws and legislations, and decentralization and stakeholders' participation through expansion of the Water-users Association (WUAs) for ditches and mesqas, establishment of the Water Boards (WB) on branch canals, as well as promotion of public awareness programmes.

- **Quotas:** by setting a maximum amount of water that can be used for a certain purpose.
- **Licenses:** for withdrawals or discharges and subject to control for a limited period of time.
- **Tradable water rights:** by the creation of a water market where stakeholders can buy and sell water rights within a well defined legal framework.
- **User charges:** pricing of water services related to the type of service and the type of water-use. Besides the cost recovery element, these charges may include demand management charges or subsidies to stimulate certain behaviour.
- **Subsidies, grants, soft loans, product charges, tax differentiation, tax allowances and other economic incentives:** to stimulate the allocation of water to certain preferred water-users, or to make undesirable behaviour less attractive.
- **Penalties:** by a system of financial and legal enforcement incentives; such as fines.
- **Awareness raising and public education:** are key instruments of Water Demand Management (WDM). The success of all other WDM tools relies mostly on users, co-operation. Thus, public education is an important complement to other WDM tools. Media campaigns and awareness seminars can contribute to conveying water conservation message, provided that such programs are directed to the right audience. This will make consumers aware of current water-use restriction, encourage water-use behaviour changes, explain why an increase in price is necessary, and disseminate information about available technologies to increase water-use efficiency. Inclusion of user interests in decision making and promotion of water conservation goals are necessary components to implement other water conservation policy tools.

2. Water Resources in Egypt

2.1. Conventional Water Resources

The values represented in this overview of Egypt's water resources and their uses are round figures and subject to variorums, Egypt's water resources consists of the following four main resources: Nile water, groundwater, rainfall and torrents and desalination.

Nile Water

The River Nile is the longest river in the world where its length is about 6850 kilometers. It ranks the sixth of the world in its catchments area, where it is about 2.9 million squared kilometers. It ranks the 24th of the world in its annual discharge, where it is about 84 BCM. Victoria Lake ranks the second of the world in its area of the natural fresh lakes, where it is about 69500 square kilometers. It lies in Africa and it is one of the River Nile sources.

The River Nile is shared by ten African countries: Burundi, Democratic Republic of Congo (DRC), Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda. The river serves as home to world-class environmental assets, such as Lake Victoria and the vast wetlands of the Sudd region. It also serves as home to an estimated 160 million people within the boundaries of the Basin, while about twice that number, roughly 300 million, live within the ten countries that share and depend on Nile water.

Nile water is the basic source of fresh water in Egypt. The River Nile, which is the main source of water for Egypt, is totally located outside Egypt's international borders. Downstream of Atbara River in Sudan, the Nile has no other tributaries and it continues as a single channel until it penetrates the Sudanese-Egyptian borders. The Nile morphology and the barren desert, that bounds the Nile Valley and Delta, constitute a geographical barrier that prevents the Egyptians from fully utilizing their territories. The River Nile provides Egypt with more than 70 % of its various water requirements. The average annual yield of the River is estimated at 84 Billion Cubic Meters (BCM) at Aswan. This yield is subject to wide seasonal variation. Nevertheless, Egypt's annual share of Nile water is determined by international agreements by 55.5 BCM. Aswan High Dam (AHD) is the major regulatory facility on the River. Its operation started in 1968 ensuring Egypt's control over its share of water and guiding its full utilization. Downstream AHD, Nile water is diverted from the main stream into an intensive network of canals through several types of control structures. These canals provide water mainly for agricultural use.

Groundwater

Groundwater is also an important source of fresh water in Egypt both within the Nile system and in the desert. Groundwater in the Nile aquifer cannot be considered an additional source of water as it get its water from percolation losses from irrigated lands and seepage losses from irrigation canals. Therefore, its yield must not be added to the Egypt's water resources but rather be considered as a reservoir in the River Nile system with about 7.5 BCM/yr of rechargeable live storage. Groundwater also exists in the non-renewable deep aquifers in the Western Desert region and Sinai. This aquifer is mostly deep with a total abstraction of about 0.5 BCM/yr.

Rainfall and Torrents

Rainfall is very scarce in Egypt, except in a narrow band along the northern coastal areas, where an insignificant rain-fed agriculture is practiced. Rainfall occurs in winter in the form of scattered showers. The total amount of rainfall does not exceed 1.5 BCM/yr. This amount cannot be considered a reliable source of water due to its spatial and temporal variability. Sparse flash floods also occur in the Sinai Peninsula and in Upper Egypt. The average range of rainfall in winter over the northern parts of Egypt is around 200 mm in Alexandria and 75 mm in Port Said decreasing gradually towards the South to be 25 mm in Cairo.

On the other hand, torrents resulting from short storm rainfall have an environmental danger in the Red Sea and South Sinai. Area studies have showed the possibility of harvesting this water and to from it by recharging groundwater, hence limiting destructive effects.

Desalination

Desalination has been used in some remote areas to provide domestic water supply for some locations along the Mediterranean Sea and the Red Sea coasts as well as in Sinai Peninsula. The capacity of the desalination plants currently operating in Egypt is much less than 1.0 BCM. Desalinated water-use is only limited to municipal uses due to its high cost of production. Nevertheless, renewable energy sources are being investigated, as they are considered promising sources for energy for large desalination projects.

Desalination has been neglected for sometime as an alternative source of water supply because of its high cost, compared with other water resources; the cost of desalinating one cubic meter is around L.E. 3-7. Recent studies showed that desalination of sea or brackish water for agricultural uses is not economically conceivable. It might be possible as a source of water supply for tourists' areas and resorts along the Mediterranean Sea and Red Sea.

2.2. Non-conventional Water Resources

The River Nile is the main source in Egypt for renewable fresh water. But there is other water resources can be exploited called "non-conventional water resources", such as: groundwater in the Nile Valley and Delta, recycling of drainage water and recycling of sewage water.

Moreover, these non-conventional water resources are not considered as independent water resources and cannot be added to Egypt's share of the fresh water. In fact, recycling programmes are to maximize the use of water resource available since Egypt's share from the River Nile is insufficient for current national demand. In other words, the recycling process contributes in enhancing the efficiency of the system.

Groundwater in the Nile Valley and Delta

The current abstraction is about 4.8 BCM/yr and it can be increased to reach a potential safe yield value of about 7.5 BCM/yr.

Recycling of Drainage Water

Reuse of drainage water in the Nile Delta has been adopted as an official policy since the late seventies. This policy calls for recycling agriculture drainage water by pumping it from main and branch drains and mixing it with fresh water in main and branch canals. The amount of recycled drainage water at present is 4.5 BCM; it can be increased to reach 7.5 BCM by year 2007 and 9.0 BCM by year 2017. There has been a decreasing trend in the amounts of water pumped into the sea with a significant increase in the amounts of drainage water reused recently. Drainage water quality should be improved by treating it in small stations on the sub drains, or treating the water of bulky drains before blend, also through the isolation of sewage arid industrial water from drainage water and reduces the utilization of pesticides and fertilizers.

Recycling of Sewage Water

In large cities in Egypt, there are few treatment plants for the collected domestic wastewater. The issue of public health is an obstacle to file expansion of using treated wastewater, but if it is used in cultivating plants that are not used directly as food, reuse of primary treated wastewater could be increased from 1.0 BCM of primary treated wastewater is being used in irrigation in specific locations outside the Greater Cairo Region at present to 2.5 BCM by 2017.

Wastewater Reuse in Egypt

Agriculture in Egypt is purely depending on irrigation; water consumption of all cropped plants is covered by Nile water. At a more distinct valuation of the water, the chemical properties of the water become more and more important for irrigated agriculture along the Nile valley and in the Delta as well as in all oases in the Western Desert. Nile water is polluted with a lot of suspended and diluted fractions, so we find suspended matter which may be deposited somewhere as a sediment, such as forming the sediments of the fertile Nile Delta lands.

Furthermore, the Nile is fed with communal and industrial wastewater, soluble salts, chemicals and drainage water from agricultural fields. Although all diluted salts are invisible to man, they play an important role in irrigation; this is often a negative role.

Traveling through the Nile Delta, along the Riverbanks and in the oases an alternative visitor recognizes the usually dark colored soil, covered with a thin white layer especially in summer. This is often the first sign of increasing salinization of the soil.

Chemically, clean water is found only as distilled water that doesn’t contain any soluble salts. The amount of soluble salts in Nile water differs from time to time and depends on the amount of flowing water. For example, the salt content in Nile water increases since the construction of AHD. Up the River or in South Cairo the salt content is about 250 mg/liter as compared to 175 mg/liter behind AHD. So for, these figures give no reason for any concern, as this is still a good quality for drinking water for humane consumption. For comparison, we may take an example for bottled mineral water where the soluble salt is 440 mg/liter.

The threat of increasing salinization of the River Nile is not coming from the construction of AHD, but from the increasing water demand and use. Water evaporates from soil and water surfaces; thus, salts remain and accumulate in the drainage water of rural communities and irrigated fields then they are drained into the River.

Drainage Water Reuse in Egypt

Drainage water is considered one of the most economically feasible alternatives when it is used for irrigation on an environmentally sound and sustainable basis. The reuse of agricultural drainage water is already practiced on a large scale in several countries. Egypt is one of the leading countries in drainage water reuse for irrigation. Annually, Egypt uses 83.4 % of its available fresh water resources in the agricultural sector. This situation illustrates the need of an Egyptian national policy for drainage water reuse.

However, increasing salinity is expected to limit full utilization of drainage water. Intrusion of saline groundwater from the Mediterranean Sea contributes to the salinity conditions, particularly in the Northern Nile Delta. Attention has to be paid to the rule: “No irrigation without drainage”.

The total area provided with subsurface drainage network reached about 4.5 million feddans nation-wide. Also about 6.6 million feddans were covered by main surface drainage network. Maintenance for both surface and subsurface drainage systems are carried out by the Ministry of Water Resources and Irrigation (MWRI) to prevent soil salinity and water logging. Cleaning open drains from weeds and removal of silt is also carried out regularly for open drains; while for the subsurface drains annual maintenance plan includes gravity flushing for collectors and high or medium flushing for the laterals.

The water conveyance network in the Nile Delta is divided into a system of main canals and main drains, collector drains, and open and subsurface field drains. This network of canals and drains is necessary to support the reuse of drainage water. The main drains are man-made ditches flowing northward where pump stations are used to lift water to the inland lakes or to the sea. The main drains in addition to being collectors of drainage water from irrigated cropped fields receive the tail-end and spillway loses of the irrigation canals. These drains also receive domestic and industrial wastewater.

Drainage water which flows out of the Delta to the sea represents part of the irrigation water that is in excess of crop evapotranspiration in addition to canal-tail water loses and water disposed into or collected by the drain throughout its course Under reuse practices, some of the drainage water is lifted out of the drains to the irrigation system at certain locations. A portion of this water flows back again to the drainage system either to the same drain or another drain and is conveyed out of the system to the sea.

New changes have been made to the organizational structure of the EPADP to enhance and improve its performance. Drainage Advisory Service Directorates were established to increase the awareness of farmers about importance of subsurface drainage networks and to demonstrate how simple maintenance works could be done. The establishment of these directorates is the starting steps to achieve the long-term strategy of privatization of Operation and Maintenance (O & M) works policy.

Agricultural drainage water is readily available to farmers who suffer shortages of fresh water supplies. Drains are located at the tail-ends of irrigation canals where the lands subject to shortages of irrigation water are usually located. Drainage water offers to the farmer a more reliable water supply independent of the regular irrigation water rotations.

Drainage water reuse projects in the Nile Delta started in the 1930s. During that period, an additional Serw pumping station was constructed to support the main Serw station which was constructed in 1928. When it was discovered that the water conveyed by the additional station was of good quality, it was separated from the main station and diverted as pumped drainage water into the Damietta Branch. In the early 1970s, Egypt adopted a long-term plan to reuse drainage water for irrigation on a more sustainable basis. To implement this plan several pump stations were constructed to mix drainage water with fresh irrigation water. The officially reused drainage water increased from 2.6 BCM/yr in the 1980s to about 4.2 BCM/yr in the early 1990s.

In addition to the above official reuse, an unofficial reuse takes place in many locations. Details of such activities can't be determined accurately because of the great number of diversions and pumping points involved. However, field observations and simple analysis cleared that drainage water is intensively unofficially reused in the Delta at rates as high as 2 BCM/yr.

Obviously the reuse of drainage water for agriculture plays an important role in the Egyptian water resources strategy. MWRI reuse policies focus on the overall supply of water for the country. According to water planners, reuse is expected to increase in the future. There are numerous variables that need attention in the reuse decision process.

The use of marginal quality water has the potential of causing serious problems of soil degradation due to salinization. There would be also a commensurate reduction in crop productivity due to irrigation water salinity. Other problems such as human health hazards are also involved. With these thoughts in mind, the Drainage Water Irrigation Project was conceived. The formulators organized the project to address the key elements concerning soil-plant-crop relationships along with socio-economic and environmental questions.

Water-Desalination Activities in Egypt

The Red Sea Governorate has two different parts, the northern part up to El-Quseir City and the southern part up to the boarders with Sudan. The northern part is supplied by two pipelines transporting water from the River Nile to some desalination plants. This part does not suffer from water problems and it has sufficient amount of water up to 2020.

In general, the Reverse Osmosis (RO) technology is predominant for this area. Solar energy can be used to power these units using photovoltaic units in stead of diesel generators. There are two types of desalination units in the Red Sea Governorate: the first type is owned by the GOE (Ministry of Rural Development) and the second type is owned by the private sector.

The total capacity of the lines is 17000 CM/day, distributed to Hurghada (7000 CM/day), Safaga (5000 CM/day) and El-Quseir (5000 CM/day).

Developing this area has been expanded south until Marsa Alam and in the future is expected to reach the southern boarders with Sudan at Shalatin and Halayeb.

The total amount of desalinated water in this area is 34750 CM/day. The units using RO technology produces 25250 CM/day and the Vapor Compression (VC) technology produces 4500 CM/day. It doesn't worth to transport Nile water to this area, since the cost of desalinated water decreases continuously.

Water-uses in the Red Sea Governorate are: domestic, agricultural, touristic and recreational. The expected major activities in the Red Sea Governorate will be tourism only. It will expand to the south in Marsa Alam and El-Quseir Cities. The coast from Hurghada to Safaga is saturated. Thus, the demand will be supplied only by desalination.

Desalinated water production using RO technology can be obtained from sea water (SWRO) or from brackish water (BWRO) or from VC technology which are widely spread in this area. RO is the dominating technology.

The main VC units are in Abu Soma Bay which produces 4500 CM/day. This is the largest VC units in Egypt. In general, the cost of the water produced by RO and VC technologies has the same qualities. Meanwhile, the maintenance of RO units is less sophisticated than it in case of VC units. Moreover, the RO units are smaller than VC units.

Water-Harvesting Activities in Egypt

The irrigated area in Egypt occupies only 3.4 % of the total area. Besides irrigated lands, there are some areas relying on rainfed agriculture; supplementary irrigation, or water-harvesting. These areas are concentrated in Sinai and in the North Western Coastal Zone (NWCZ). These areas represent a narrow strip along the Mediterranean Sea.

Due to limited amount of rainfall (around 100-200 mm/yr) in these areas and for Arable weather conditions, efficient water-harvesting system has a great importance, as productivity of these areas can be improved by improving water-use efficiency and water-harvesting practices.

In many cases understanding the socio-economical factor and behavior of people will be more important than implementing aspects. It is very important for these systems to be acceptable to the farmers both socially and economically. Unless people themselves are actively involved, water-harvesting projects will not be sustainable and people finally will abandon them. Involvement of people can take different form starting from constructing the system, monitoring of rainfall and runoff, performing agricultural activities and system maintenance. The system characteristic should be close to either culture and local conditions and simple enough to implement and maintain. The water-harvesting system should be self-supportive so that farmers or use will not look for additional income.

The preference of a system rather than another depends on many factors; technical and socio-economical and environmental factors. For example, the constructing of cistern is relatively high but they offer an ideal solution to many problems; it will provide a source of water available in case of shortage. It also doesn't require maintenance and keep water at excellent quality if the catchment's area is well protected. The main social function in the widespread of cistern is become they are owned by individuals. People try to avoid common project owned by the society not by the individuals because they may create some kind of conflict.

The construction of dikes across Wadi courses should be implemented carefully so that so that the upstream users will not affect the downstream by holding the water from downstream flow. There should be rules and norms governed by the society to regulate the height of dikes. For example, the dike should not be more that 50 cm height. It should also be equipped with spillway to allow water flow safely to the downstream users. When land is publicly owned, this kind of regulation must be established. In areas where spate irrigation is common practices, priorities for irrigation are given to the upstream users.

Real farmers are those who accept system of high economic value such as terraces although their construction increases the maintenance are high. As the cost of construction increases the maintenance requirement are reduced. For example, stone terracing are expensive to construct but their annual maintenance is less than earth terraces.

3. Water Demand in Egypt

Egypt's water demand increases with time due to the increase in population and the improvement of living standards as well as the government policy to reclaim New Lands and encourage industrialization. The cultivated and cropped areas have increased over the past few years and will continue to increase due to the government policy to add more agricultural lands.

3.1. Water Demand for the Agricultural Sector

This demand represents the largest component in the national water-use. The largest consumers of water irrigation are rice and sugarcane due to the high water requirements in addition to occupying considerable areas. The average annual crop consumptive use has been estimated to be more than 40.0 BCM. The total diverted water to agriculture from all sources (surface, groundwater, drainage reuse and sewage reuse), including conveyance, distribution and application losses is estimated at about 61.0 BCM/yr. Water policies of the 1970s and early 1980s gave a significant advantage to New Lands development. However, recent changes in price and other policies particularly the reduction/elimination of government fertilizer and energy subsidies place farmers in New Lands at a disadvantage. Meanwhile, the annual evaporation from open water surfaces is estimated to be about 3.0 BCM/yr using the total water surface area of the River Nile inside Egypt and the irrigation network (canals and drains) and an average annual rate of evaporation. This amount varies slightly from one year to another according to climatic conditions (temperature, humidity, wind speed and solar radiation) as well as the rate of infection of canals and drains with aquatic weeds.

3.2. Water Demand for the Municipal Sector

This demand includes water supply for major urban and rural villages are estimated at 4.6 BCM/yr. A part of that water comes from the Nile system and the other part comes from groundwater sources. A small portion of the diverted water (about 1.0 BCM) is actually consumed while the remainder returns back to the system. The major factor affecting the amount of diverted water for municipal use is the efficiency of the delivery networks. The studies showed that the average efficiency is as low as 50 % and even less in some areas. The cost of treating municipal water can be reduced significantly as the efficiency of the distribution network increases. It is expected to increase significantly due to the population growth as well as due to increase in per capita demand.

3.3. Water Demand for the Industrial Sector

There is no accurate estimate for the current industrial water demand especially with the new government policy to encourage private sector participation in industrial investment. The estimated value of the water requirement for the industrial sector is about 7.53 BCM/yr. A small portion of that water is consumed through evaporation during industrial processes (only 0.79 BCM) while most of that water returns back to the system in a polluted form.

In summary, the currently total available amount of water for use is 76.3 BCM/yr. the available amount of water of River Nile for use is 55.5 BCM/yr. whereas, water demand for different sectors is about 73.1 BCM/yr. Recycling and better management overcomes this gap between the needs and availability of water. Currently, abstraction from the Nile aquifer is about 4.8 BCM/yr. An amount of 4.5 BCM/yr of drainage water is now used directly after mixing with fresh water. Less than 1.0 BCM/yr of treated (recycled) wastewater is reused for irrigation.

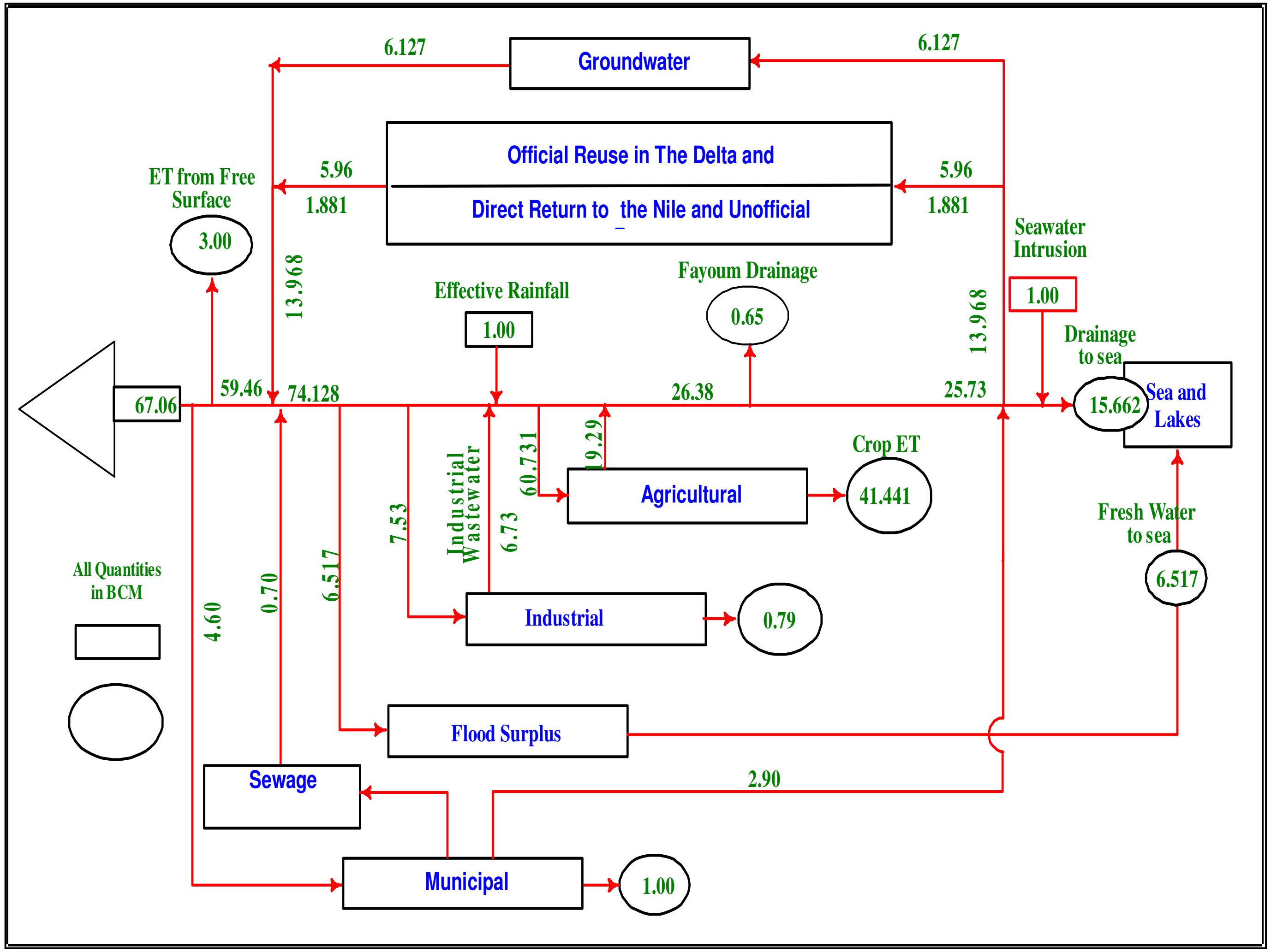
Table 1 and Figure 1 represent the national water balance of Egypt for 1999/2000. The main channel of the River Nile and a part of the irrigation network are being used for navigation. Water demand, specifically for navigation, occurs only during the winter closure period when the discharges to meet other non-agriculture demand is too low to provide the minimum draft required by ships. This water goes directly to the sea as fresh water. After changing winter closure system by dividing Egypt into 5 regions instead of two, the amount of water released for navigation is considered to be insignificant.

Table 1. Egypt's National Water Balance for 1999/2000 (in BCM)

Water Resources	BCM	%	Water Demand	BCM	%
Conventional:	65.5	85.8			
Nile Water	55.5	72.7	Agriculture	61.0	83.4
Groundwater	7.5	9.8			
Rainfall and Torrents	1.5	2.0			
Desalination	1.0	1.3	Municipality (Domestic)	4.6	6.3
Non-conventional:	10.3	13.5			
Groundwater in the Nile Valley and Delta	4.8	6.3			
Recycled Drainage Water	4.5	5.9	Industry	7.53	10.3
Recycled Sewage Water	1.0	1.3			
Improvement of the Irrigation System	0.5	0.7			
Total	76.3	100	Total	73.1	100

Source: Abdel-Aziz, 2003, "The case of Egypt: Decentralization and Water-user Participation", Water Demand Management Forum, Decentralization and Participatory Irrigation Management, Egypt.

Figure 1. Egypt's National Water Balance for 1999/2000 (in BCM)



Source: Abdel-Aziz, 2003, "The case of Egypt: Decentralization and Water-user Participation", Water Demand Management Forum, Decentralization and Participatory Irrigation Management, Egypt.

4. Water Policies in Egypt

Egypt prepared its first water policy in 1975. Since then, several water policies were formulated to accommodate the dynamics of water resources system, and there objectives and priorities are different. Egypt Water policies are dynamic and they were reformed many times according to several aspects; such as water supply availability, using modern techniques, socio-economic impacts and other relevant factors.

The 1975 Water Policy

This policy is one of the earliest water Policies based on two stages to achieve two objectives; the objective of the first stage could be achieved through drainage water reuse (12.2 BCM) and groundwater development in the Delta (0.5 BCM). The objective of the second stage could be achieved by carrying out the Upper Nile conservation projects. Horizontal agriculture expansion for an area of 1.50 million feddans was projected to utilize Egypt estimated share from the Upper Nile projects.

In 1977, the Water Master Plan Project started. This project was interested in collecting different relevant data: hydrological, meteorological, agricultural, municipal, industrial, economic, physical, Quality, demographic and ecological data, as well as data on the irrigation and drainage and administrative Systems.

The 1980 Water Policy

In 1980, Ministry of water Resources and Irrigation (MWRI) estimated the available water resources and their uses. It projected the water resources status every five years up to 2000. The policy also stated that in the long-run additional water could be saved from the Irrigation Improvement Project (TIP), estimated at 5.0 BCM and the benefits of Jonglei Canal would be available. This policy didn't specify the mean of the long-run in terms of how many years.

The 1986 Water Policy

By the end of 1982, MWRI revised the 1980 Water Policy based on realizing some facts; the halting of Jonglei Canal construction and the expected effects of the IIP on quantity and quality of reused drainage water called for the revision of the 1980 Water Policy.
The assumptions for this policy were:

- Jonglie Canal would be in operation before 1992/1993.
- Some pumping stations would be constructed to expand the Drainage Reuse Programme.
- About 2.5 million feddans would be Improved by the Project.
- About 1.5 BCM of the closure period water could be saved in the Northern Lakes.
- About 50 % of the Nile Valley and Delta groundwater utilization projects would be accomplished before 1992/1993.

The 1990 Water Policy

In 1990, the 1986 Water Policy was updated. The constructions of the halt of Jonglei Canal besides the new agricultural expansion policy were the motivation for preparing the 1990 policy. The assumptions of this policy were:

- Jonglie Canal would be in operation by 2000.
- Drainage water reuse has the potential to increase from 4.7 to 7.5 BCM by 2000.
- By 2000, extraction of groundwater could increase from 0.5 to 2.5 BCM, while groundwater extraction in the Delta and Valley could increase from 2.6 to 4.9 BCM.
- Fresh water that flows to the sea during the low requirements period could decrease from 1.8 to 0.3 BCM by 2000.
- The IIP might save 1.0 BCM by 2000.
- About 1.6 million feddans could be added to the current agricultural land (7.4 million feddans in 1990).
- Municipal water–use efficiency would increase from 50 % to 80 %. Therefore, domestic demand could not increase by 2000.

New Paradigm for Policy Formulation

Formulation of Egypt Water Resources Policy for this century requires a major shift from the classical paradigm used in water resources planning and management to a new innovative paradigm. Dynamic interrelationships among the components of water resources system impose the integrated approach on Policy makers. Previous experience shows that when an action or a strategy is planned and implemented in isolation from other components of the system, disruptive impacts are perceived. Using the ecological, social and economic systems as boundary conditions for water resources system is an obsolete assumption. A multidisciplinary dialogue has to be adopted m the policy formulation process.

Uncertainty has to be explicitly considered in the long–run national policy formulation rather than just being ignored. Conducting a deterministic analysis rather than stochastic one should be disengaged. Increasing environmental awareness and quality deterioration of the limited fresh resources necessitate the replacement of water quantity management by quantity and quality management. Public and stakeholder participation in water resources planning and management is dictated through privatization and progressing role of the Non-Governmental Organizations (NGOs). Transparency of the policy formulation process and general public approval is the key elements to achieve the policy objectives.

These problems have been irradiated to inappropriate management practices; such as drainage water reuse. This does not necessarily stop or prohibit such strategies, rather take the proper measures and actions to control their drainage effects conserving environment. Similarly, the cost of environmental deterioration; such as cultural heritage damage and natural resources depletion is not acceptable to be paid by the society.

Egypt's Future Water Policy

The most recent water policy drafted in 1993 included several strategies to ensure satisfying the demand of all water-uses and expanding agricultural area. According to next century approaches, some of these strategies will be discarded, others will continue with more or less emphasis and new strategies have to be adopted to give the best Water Demand and Supply Scenario for 2017 (Table 2).

Table 2. Egypt's Water Demand and Supply Scenario for 2017

Demand Scenario 2017	(BCM)	Supply Scenario 2017	(BCM)
Agriculture	67.0	Share of Nile including Jonglei	57.5
		Nile Aquifers	7.5
Evaporation losses an navigation	3.0	Drainage and waste-water Reuse	10.4
Urban water	7.0	Ground and surface water in Sinai	5.3
Industry	10.0	Changes in cropping pattern	3.0
		Irrigation improvement	4.0
Total	**87.0**	**Total**	**87.7**

Source: National Water Research Center (NWRC), 1999.

Optimum Utilization of the Available Water Resources

This indicates the necessity of setting a future integrated plan for rational utilization of the available water resources to minimize the losses and maximize the return of each water unit. This concept implies the importance of specifying priorities of the several uses of water according to its revenue. Executive strategies for optimum utilization of the available resources include the:

- **Reducing water losses (evaporation and infiltration) by:**
  - Using pipes or lined ditches in new reclaimed areas, which have high propensity to reduce infiltration.
  - Developing the integrated use of surface and ground water to reduce losses of conveyance including evaporation.
  - Updating utilizing modem methods of weed control to achieve efficient conveyance besides reducing evaporation losses.
- **Changing the crop pattern to save water by:**
  - Keeping the current areas of sugar cane and expanding areas of sugar beet gradually.
  - Reducing rice area to be 0.7 million Feddans, which is the minimum limit for protecting the Delta from seawater intrusion.
  - Decreasing the gap between net returns of winter cultivation and summer cultivation.

Regional Co-operation

The co-operation between the riparian countries has started since 1967 with assistance of the United Nations Development Programme (UNDP). This co-operation should be strengthened the activities of the River Nile Basin Action Plan (NRBAP) for the purpose of the Nile Basin sustainable development for the benefit of the riparian countries.

In spite of efforts done to conserve water resources of the River Nile and to control water resources in the lower Nile Basin in Egypt and Sudan, demand on water resources for various uses is increasing, especially for irrigation. The amount of water needed by the riparian upstream countries to meet food requirements of the growing population will be also increasing. So, additional water resources should be created to meat the comprehensive water demand of the Nile Basin countries in the two coming decades.

This is possible by reducing evaporation and evapotranspiration losses in the swampy areas. Such water resources management can be achieved by means of development schemes of yearly and over storage in the lakes, taking into account the environmental constraints in the scope of regional co-operation among the Nile Basin countries.

The distinctly differing meteorological, hydrological and physical characteristics of the White Nile Basin and its swamps and lakes and the variable seasonal flows of the Ethiopian Plateau make the development options are great.

Specific yield of the River Nile is very low compared with other big rivers in the world, because it is passing through a vast area of arid and semi arid areas in Egypt and Sudan. The potential of the hydropower in some countries like Ethiopia and Uganda is significant. The approach to develop the River differs from an area to another, and socio-economic benefits can be gained from tile River by different approaches.

5. Water Valuation

The challenge is to manage water in a way that reflects its economic, social, environmental and cultural values for all its uses. Water should be treated as a basic human right but it should not be provided free of charge. A balance should be struck between pricing of water as commodity and the cost of providing it in a good quality and sufficient quantity. Growing recurrent costs for O & M of irrigation services and facilities are creating huge budgetary demand in Egypt. In addition, public irrigation is heavily subsidized and has become a fiscal drain. In 1995, the public subsidy to irrigation services was almost L.E. 670 million. Greater emphasis is now put on cost recovery mechanisms whereby the resources for O&M, minimally, must come from the direct beneficiaries, the water-users.

5.1. Cost Recovery for Irrigation System

A package of demand-oriented measures have been prepared and applied to the Egyptian agricultural sector under the IIP. WUAs that were established under the IIP serves as an excellent example of the effect of user involvement and co-operation on the system management.

Although all the users here are farmers who belong to the same economic sector, it is the concept of stakeholder involvement in decision making during the various stages of planning and implementation, which is emphasized. When the user is involved from an early stage, it is evident that he will accept the proposed improvements and will be able to operate and maintain them easily afterwards. Moreover, they resolve conflicts between themselves automatically as they have to share a common resource.

In order to achieve the user involvement objective, a department for water advisory service was established under the irrigation improvement sector. One of the main functions of this department is to help in the transfer of the management of the mesqa to farmers and help them resolve conflicts and problems.

The success of the IIP in forming water-users' associations forced the parliament to issue a legislation of such associations in which it was defined as private organizations owned and operated by its members of the water-users of the water course for their own benefit, and work in the field of water-use and distribution and all the related organizational activities for the purpose of raising the agricultural productivity.

Repayment of the full capital cost of improved mesqa, excluding interest, over a period not more than twenty years and establish a special fund within MWRI to finance future mesqa improvement beside recoveries from farmers, the fund would be financed from budgetary transfers and foreign grants and loans.

The payment for mesqa investment expressed as a proportion of incremental income attributed to irrigation improvements varies from 15 % to 25 %. This shows the ability of beneficiaries to pay; it also shows there is strong incentive for farmers to participate in the irrigation improvement program.

5.2. Cost Recovery for Subsurface Drainage

Irrigated agriculture represents 98 % of the Egyptian agriculture. Typical adverse impacts of perennial irrigation are soil salinity and water logging. In 1970 Egypt launched a large-scale drainage program. The programme was planned to cover the entire old agricultural land in the Nile Delta and Valley. After finishing the installation of the national drainage system, EPADP will continue to operate and maintain it in addition to rehabilitation and replacement of the old drainage systems.

Egypt's drainage programme is considered to be one of the largest, if not the largest drainage programme in the world. It has been extremely successful preserving Egypt's soil and allowing for high crop production.

An increase in crop yield by more than 20 % due to installation of the drainage system has encouraged farmers to participate in the programme and pay for it.

A similar approach of recovery the investment costs for mesqa in the IIP is followed in the case of subsurface drainage investments, which have been made over more than five million feddans during the last 30 years.

5.3. Cost Recovery in New Lands

In New Lands, farmers are also responsible for investment costs for all infrastructures including downstream of the booster pumps that draw from distributary canals, serving areas in the order of 100-200 feddans. Such investment may either be undertaken independently at farmer's expense or by government with cost recovery according to the rules set out above.

Thus, the policy of the GOE with respect to capital cost recovery is to recover no charges above the delivery point (mesqa head in Old Lands, booster pump in New Lands) and a proportion of the investment costs below the delivery point. Thus, the subsidy

On capital investments is in the order of 80 to 90 %. The current policy for capital cost recovery should be reviewed in the light of the high subsidy resulting from current procedures.

5.4. Cost Recovery for Operation and Maintenance

The O & M costs are the responsibility of farmers below the delivery point. Failure to fulfill this obligation results in the work being undertaken by MWRI and charged to the farmers on average general, farmers pay L.E. 18/feddans/yr for mesqa maintenance in Old Lands, either to the government or as a contribution of labor cost recovery for O & M above the mesqa from farmers has been through land tax.

Nowadays, Egyptian farmers pay very little in taxes relative to their incomes. Under the current system, as agricultural incomes rise in response to liberalized market conditions, tax revenues do not automatically follow.

Farmers with 3 feddans or less of land and who have no other source of income are exempt from land tax and additional taxes attached to agricultural land tax. These exemptions do not apply if taxpayer has other sources of family income. However to obtain an exemption, farmers must apply to their local authorities each year and go through an enormous bureaucratic process, as a result most farmers seem to pay their land tax whatever the size of their holding.

Settlers on New Lands, being newly graduates, farmer landless peasants, or investors, are given a grace period of ten years before they are subject to any taxes. Total land tax collections for year 2000 came to L.E. 133 million at an average of L.E. 20/feddans/yr. In addition most farmers pay an additional 15 % of the land tax to their local administrative authorities. Other taxes paid by farmers in addition to land tax for other local services, fees, stamp duties, etc. The average payment is about L.E. 15/feddans/yr.

Most farmers pay land tax based on a valuation done in the late 1980s. This tax ranges from less than L.E. 10/feddans to no more than L.E. 35/feddans in no case does it seems an excessive burden on the farmers.

The GOE has frozen the land tax for five years at its current rates as a measure to palliate the impact of the implementation of New Lands law which took effect on the 1St of October, 1997. Farmers are aware of this and appreciate it.

6. Agricultural Policy Reform in Egypt

In the early 1980s, Egypt started a serious agricultural reform programme. The implementation of agricultural policy reform programme was designed to prepare the agricultural sector for the transition of the Egyptian economy to a free-market system. The Ministry of Agriculture and Land Reclamation (MALR), with the support of the United States Agency for International Development (USAID), designed two agricultural policy reform programmes; the first started in 1987, and the second continued until 2002.

The first policy reform programme was under the USAID-funded Agricultural Production and Credit Project (APCP), which was implemented from1987-1995. The policy reform component of APCP focused mainly on the agricultural sector, with limited policy reforms in related areas.

By the end of APCP, there was a need for a broader policy reform programme to deal with the entire agribusiness system, which includes the agricultural sector and parts of other sectors. The second policy reform programme was designed to work with several ministries in order to achieve a liberalized agribusiness system in Egypt. This was the Agricultural Policy Reform Programme (APRP), which started in 1996 and continued until 2002.

Thus, the policy reform process can be described in several phases. They are the pre-reform era (1982-1986), the first phase of reform (1987-1989), the second phase of reform (1990-1995), the third phase of reform (1996-1999), and the fourth phase of reform (2000-2002). Indeed, reform is a continuous and dynamic process, which should continue after the end of USAID projects.

6.1. Pre-Reform Era (1982-1986)

In the early 1980s, MALR started studying the impact of reducing credit and price subsidies on agricultural production and consumer prices. Reducing credit and price subsidies was part of the national policy for moving toward a liberalized economy. These studies were key first steps in MALR's preparation for leading the way in economic liberalization. These studies showed that efficiency would increase after the decontrol of agricultural inputs and outputs in Egypt. As a result of these studies, the GOE started step-by-step reductions of the subsidies on some agricultural inputs, such as animal feed.

6.2. The First Phase of Agricultural Policy Reform (1987-1989)

In the mid 1980s, the GOE began to promote the long-term goals of reform in the agricultural sector and strengthen market-based incentives. In the late 1980s, the privatization concept was introduced to reduce inefficiency in public sector management. The GOE preferred to have a transition period between the public sector and the private sector eras; this was begun by issuing a new law to reorganize the public sector into what are called "holding companies". Agricultural markets and cropping patterns were liberalized, except for those of cotton, rice, and sugarcane. During this period, the GOE retained its control over cotton and sugarcane production and marketing, but rice was partially liberalized by reducing the size of the compulsory delivery quota and by allowing rice producers to sell more of their output to private dealers.

6.3. The Second Phase of Agricultural Policy Reform (1990-1995)

In the early 1990s, the GOE used privatization and liberalization as tools of resource reallocation to achieve the goal of economic efficiency. In the agricultural sector, rice production and marketing were liberalized. The private sector started its involvement in agricultural input distribution with an eye towards full liberalization. It was very important to have a transition period while moving to the free market system to avoid harmful effects that might result from sudden liberalization. This was the preparation for competition among the private sector, co-operatives, and public sector agricultural companies in the agricultural input and output markets. By 1994, Cotton market was partially liberalized by permitting private sector traders to buy cotton seed from farmers, gin it, and sell lint cotton to textile holding companies. However, private sector firms couldn't export cotton.

6.4. The Third Phase of Agricultural Policy Reform (1996-1999)

In the late 1990s, the GOE continued its policy reform programme with USAID support. The policy reform programme covered five policy areas, they are:
Price, markets, and trade.

- Private investment and privatization in agribusiness.

- Agricultural land and water resource investment utilization and sustainability.
- Agricultural sector support services.
- Food security and poverty alleviation.

One of the main accomplishments of the reforms under this phase was to better match water supply and demand. After giving farmers the right to choose their cropping pattern, the GOE could no longer estimate water demand based on its plan for crop production. Thus MALR implemented a scientific and practical method (farmers' planting intentions survey) to estimate water demand. Then MWRI used this information to calculate and release the appropriate amount of irrigation water. The GOE introduced an Egyptian cotton logo. MALR issued a decree prohibiting the use of child labor in agriculture, especially in cotton fields, and implemented a comprehensive child labor public awareness campaign. It improved the agricultural information system through more scientific data collection methods. Technical assistance and training programmes were provided to support the improvements in the agricultural information system.

6.5. The Fourth Phase the Agricultural Policy Reform (2000-2002)

In the early 2000s, the GOE continued its policy reform programme, focusing on three parts:

- Agricultural land and water resource investment utilization and sustainability.
- Agricultural sector support services.
- Food security and poverty alleviation.

In this phase the programme helped in improving policies for water management. The programme also facilitated public participation in decision-making regarding planning, development, and management of Egypt's water resources. In addition a policy was developed to encourage the commercial production of crops irrigated with wastewater, especially trees. Cotton testing by the Cotton Arbitration and Testing General Organization was improved, and the fiber quality information was disseminated better. MALR also used improved fisheries to enhance employment, incomes and nutrition by restocking the Nile in Upper Egypt.

As can be seen all policy reform activities paid a strong attention to water resources, utilization of water and crop-water relations.

6.6. Control of Water Demand of Major Agricultural crops in Egypt

In the recent water policy, published by MWRI, the year 2017 is taken as time horizon. It is assumed that by that year the first phase of Jonglei Canal is completed, which would add 2.0 BCM to Egypt's annual share of the Nile water. Other assumptions on the supply side are:

- Rainfall and flash flood harvesting increases from 1.0 to 1.5 BCM/yr.
- Groundwater mining in the desert and Sinai increases from 0.57 to 3.8 BCM/yr.
- Wastewater reuse increases from 0.2 to 2.0 BCM/yr.

- Desalination of sea water is applied for high value use in the coastal areas only.

For the estimation of the agricultural water demand, it is assumed that 3.5 million feddans (including 1.2 million feddans from previous horizontal expansion measures) will have been added to the land to be irrigated by 2017.

It is assumed in the computation of the water balance that 4.0 BCM/yr can be saved by the further implementation of irrigation improvement is estimated on the basis of an assumed per capita use of 120 litters/day, a distribution efficiency of 60 % and the expected increase of the population to 83.1 million by 2017.

In the process of agricultural reforms controls on the cropping pattern have been removed from virtually all crops except:

Sugarcane Production in Upper Egypt

The very high yielding crop is cultivated on a contract basis on about 0.3 million feddans. The area under cultivation is closely linked to the established processing capacity (currently about ten million tons of cane) in the large public sector sugar factories concentrated in a few districts in Upper Egypt. Since production has meanwhile reached about 14 million tons of cane another factory is planned to be built at Aswan.

Rice Production in Northern Delta

MWRI estimates that at least 0.9 million feddans of rice cultivation are required of the upcoming water shortages the current policy and legal provisions aim at keeping rice cultivation below one million feddans in specific and annually to be earmarked areas of the northern Delta. Due to relatively high financial returns (very high yield levels and attractive farm gate prices) and declining profitability of competing summer crops like cotton (market and price problems mainly caused exceeded with more than 1.5 million feddans during the last years by far the administratively permitted area of about one million feddans. The development was also supported by an above average water supply situation. Rice has meanwhile even become an important export crop (0.45 million tons in 1997). With recent stabilization of cotton markets and prices and decline of rice prices the cultivation of rice is likely to be lower this year.

Cotton Production in Egypt

Cotton, especially varieties that have to be cultivated in designated areas.

Tree crops in Egypt

Tree crops are not permitted to be expanded in the Old Lands. A major existing tree crop is citrus with about 0.3 million feddans. Large parts of the plantations are over-aged and heavily infested with pests and disease and cultivation is characterized in many farms by poor crop management and unsuitable flood irrigation techniques (transmitting diseases) resulting in low production, quality and productivity levels. Compared to international standards in the basin of the Mediterranean Sea, the Egyptian citrus growers just reach up to 25 % of their respective yield potential.

In general, there is an agreement to change cropping pattern in Egypt to cope with water situation according to the following:

- Replacing sugarcane cultivated area gradually by sugar beet, especially in Upper Egypt taking into account the lifetime of current sugar factories which were designed to process sugarcane.
- Reducing rice cultivated area to about 0.9-1.0 million feddans at most which be sufficient to satisfy national demand, provide some potential for export, and prevent soil salinization and seawater intrusion.
- Replacing current rice varieties by new shorter-lifetime rice varieties, which have higher productivity and less water requirements due to their shorter lifetime.
- Developing new crop varieties using genetic engineering that have higher productivity and less water consumption.
- Narrowing the gap between net revenues of similar seasonal crops to encourage less water consumptive crops.
- Designing an indicative cropping pattern for each region in the country based on climatological conditions, soil characteristics, and water resources availability in terms of quantity and quality.
- Farmers should be advised to follow the indicative cropping pattern or pay for excess water if they deviate.

6. Recommendations

- o Strengthening the institutions dealing with water supply, demand and management by:
  - Providing sufficient funds for water resources and demand.
  - Providing necessary equipments and tools.
  - Training of staff inside and outside Egypt.
- o Enhancing co-operation and co-ordination among the concerned bodies in charge of water management and water use.
- o Increasing public awareness to the importance of water use by different means of media i.e. TV presentations and radio programmes…etc.
- o Encouraging research scientists to produce plant varieties of short duration, less water requirements and salt tolerant to reduce water demand.
- o Striking a balance between crops requiring high and law water demand in the cropping pattern.
- o Strengthening legislations related to violation or water mis-use.
- o Emphasizing environmental impacts of water management at all levels especially at rural areas.

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